Site-Specific Iron
Siltronic Corporation

FFS Follow Up Meeting – DEQ NWR

May 27, 2008

Maul Foster & Alongi, Inc.

623231

Topics

- Overview/FFS Alternatives Review
- Support for Recommended Alternative
  - Pilot Study Results
- DEQ Concerns
  - Iron from EHC
- Iron
  - Sources and Sinks
  - Data
- Conclusions

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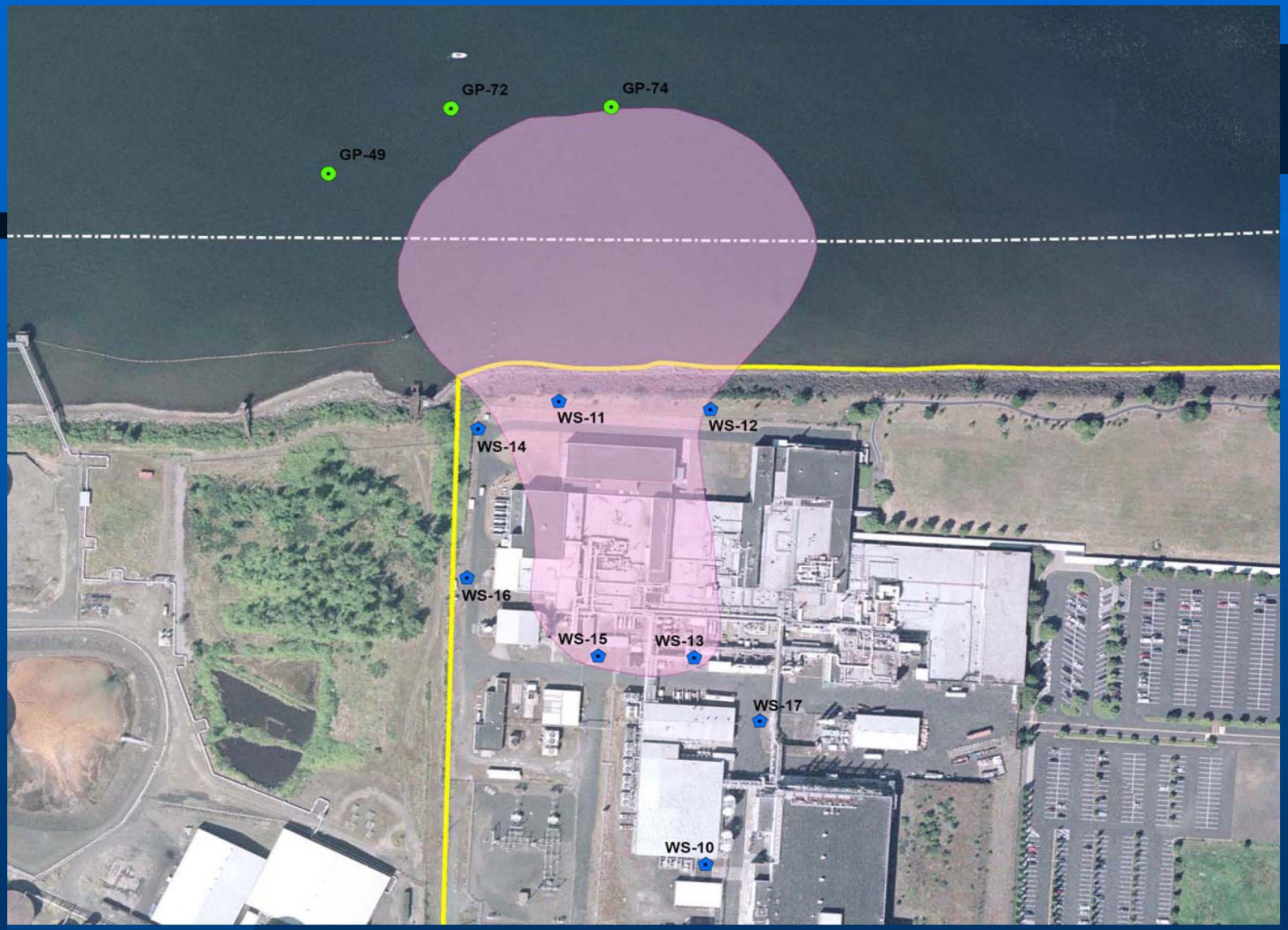

TCE-related LOF (all media)

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Siltronic FFS - Alternatives

Alternative	Non-Fiscal Balancing Factors		Cost		All Categories	
	Sum	Average Score	Estimated Cost ($ Million)	Cost Score	Total	Total Average
Alternative 1: No action	7.5	1.88	0	0.0	8	1.5
Alternative 2: Source Area Treatment, Natural Attenuation for Downgradient Plume/Area 1	11.0	2.75	$5.8M	4.0	15	3.0
Alternative 3: Source Area Treatment & Riverbank PRB at Top of Slope	**14.0**	**3.50**	**$9.4M**	**3.0**	**17**	**3.4**
Alternative 4: Source Area Treatment & Riverbank PRB at Toe of Slope	11.0	2.75	$12.8M	2.0	13	2.6
Alternative 5: Source Area Treatment Groundwater Extraction at Riverbank	9.0	2.25	$15.3M	1.0	10	2.0
Alternative 6: Groundwater Extraction at Riverbank Only	8.0	2.00	$9.5M	3.5	12	2.3

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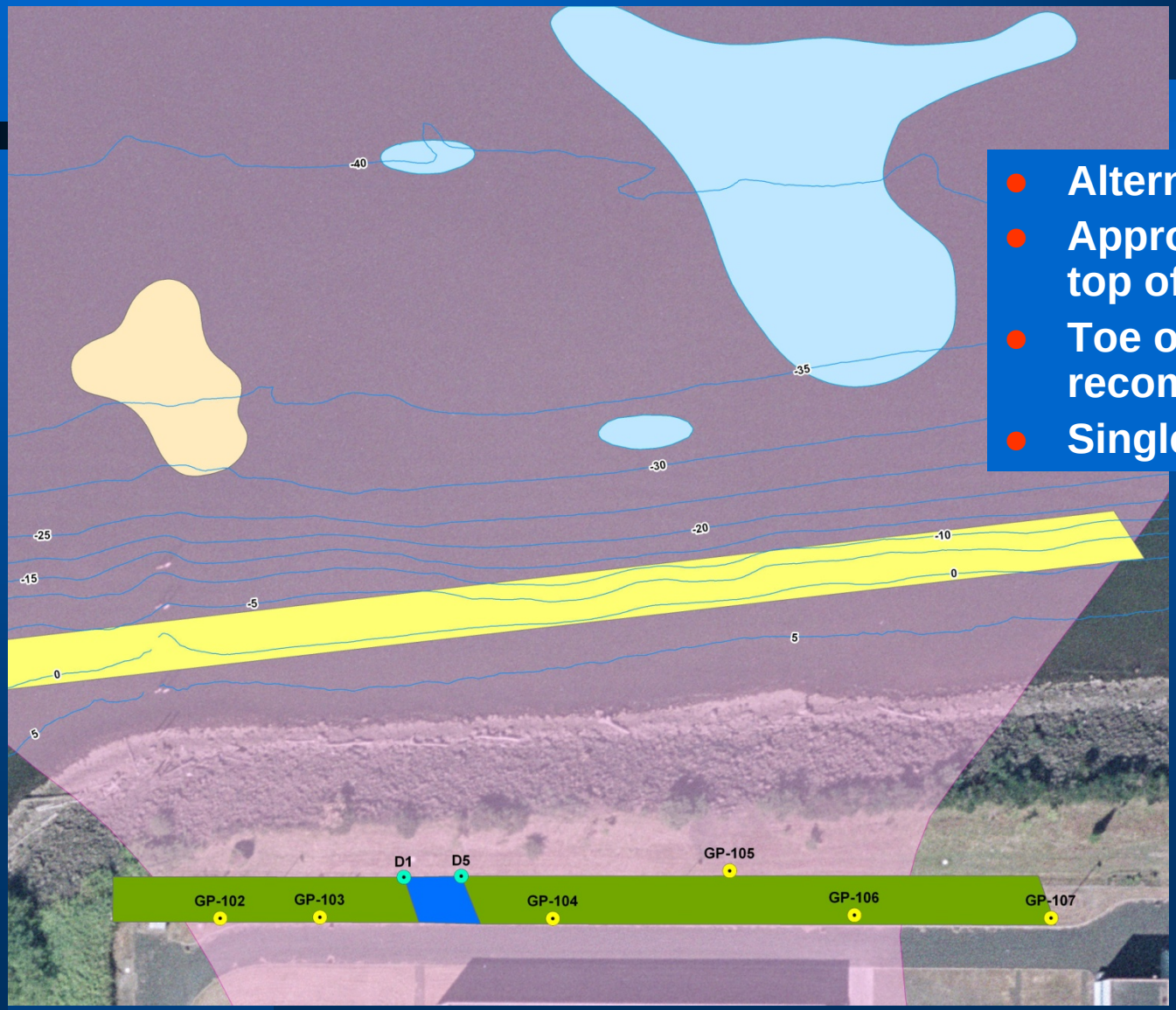
Siltronic FFS
Riverbank Injection



- Alternative 3a only
- Approx. 400 linear ft. at top of bank (green)
- Toe of slope (yellow) not recommended
- Single injection

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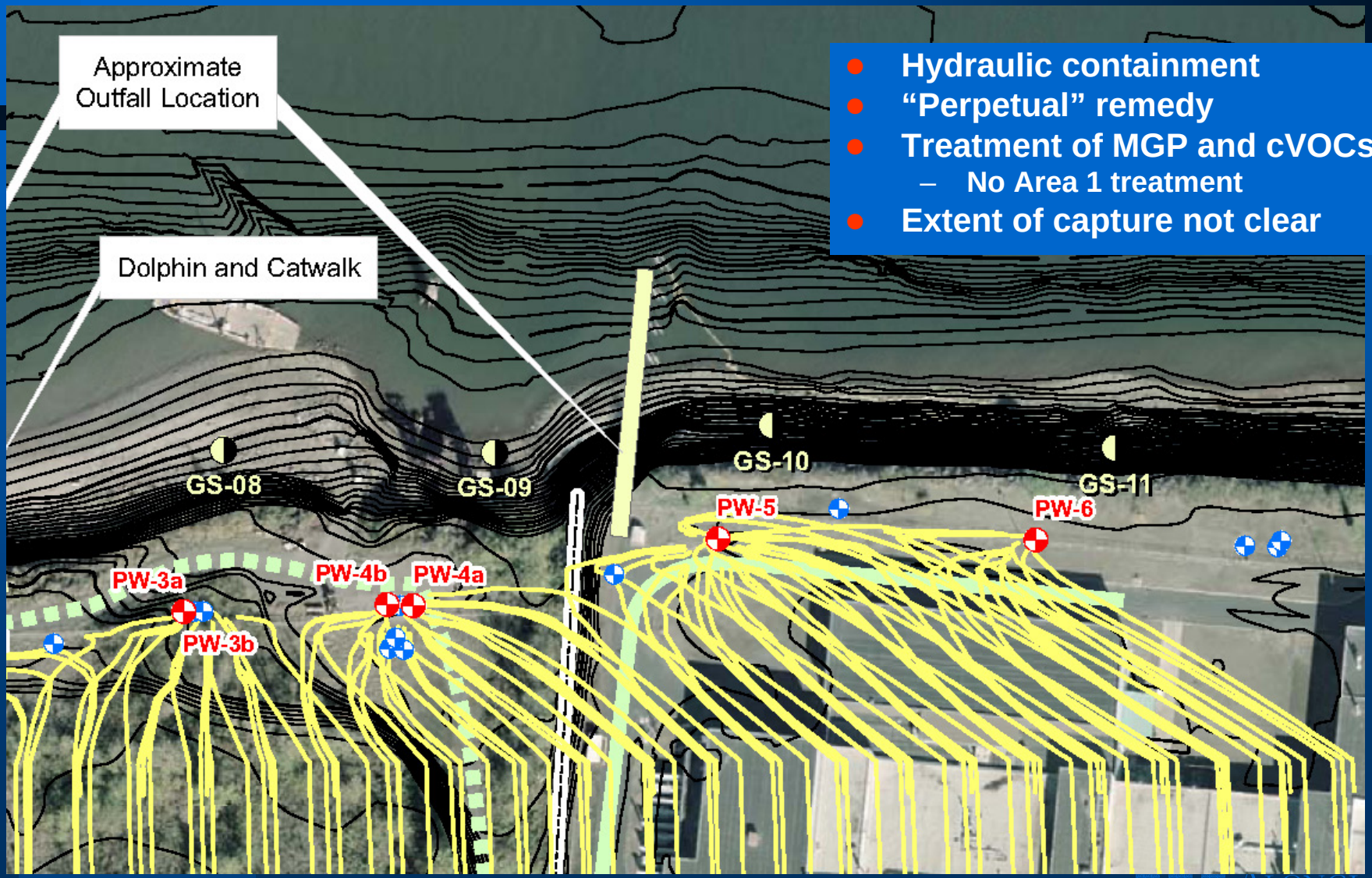
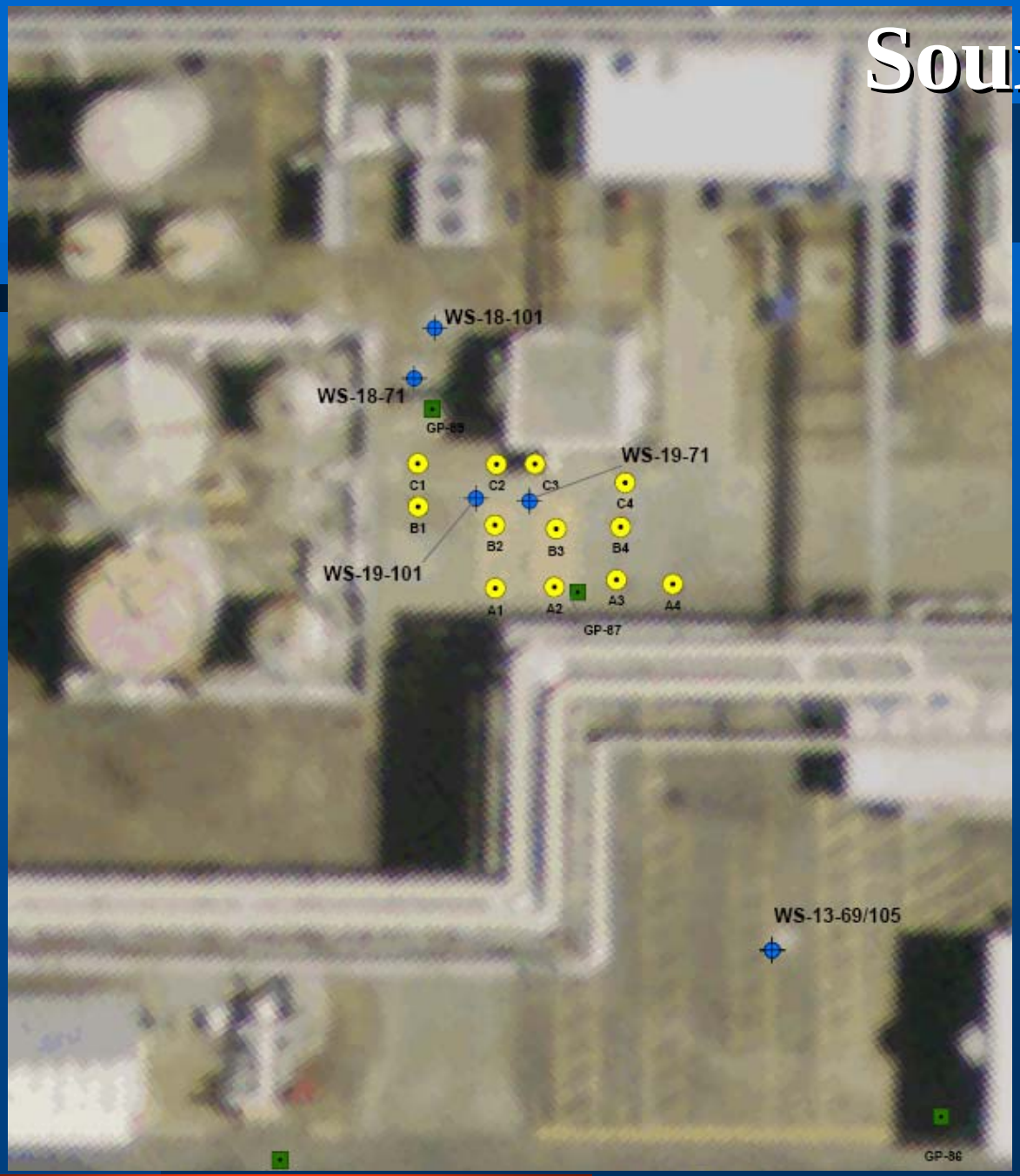
NWN FFS
Recommended Alternative



- Hydraulic containment
- "Perpetual" remedy
- Treatment of MGP and cVOCs
  - No Area 1 treatment
- Extent of capture not clear

Source Area Layout



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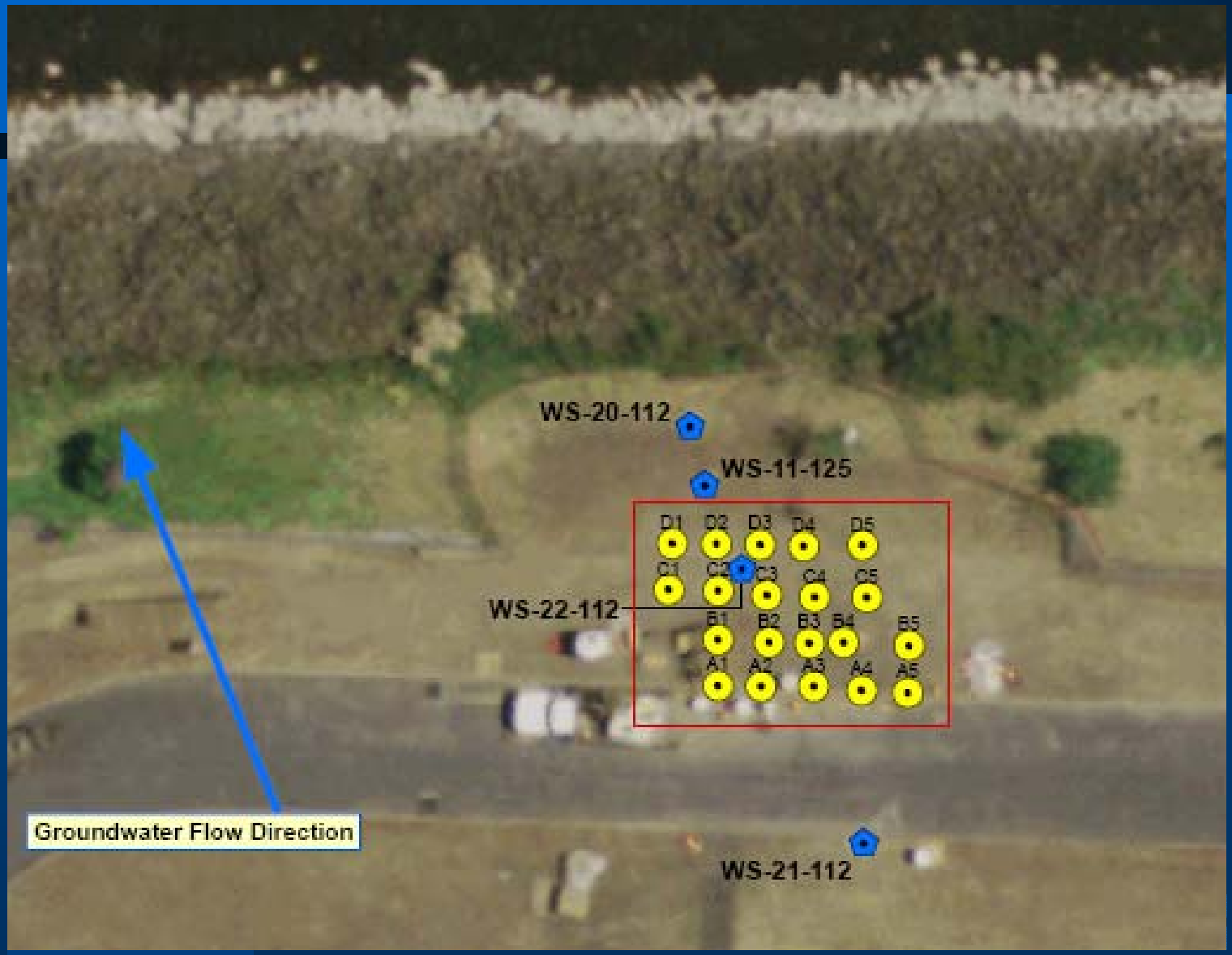
Riverbank Layout



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Primary Results

- **Source area objectives**
  - **Reduced TCE mass in source area by 94-99%**
  - **Enhanced bio treats potential TCE DNAPL zone**
  - **Overcame DCE stall – significant ethene and chloride production**
- **Riverbank objective**
  - **TCE, DCE, VC – ND or below SLVs at furthest downgradient well and in PRB**

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Results

Source Area - CVOCs

Source Area		Concentration (ug/L)				Percent Reduction
Well	Date	TCE	DCE	VC	CVOCs	Total CVOC
WS-19-71	Jun-06	6,500	89,010	30	95,540	-
(within PRB)	Feb-08	ND	120	10,500	10,620	88.9%
WS-19-101	Jun-06	92,900	39,497	22	132,419	-
(within PRB)	Feb-08	ND	94.3	156	250	99.8%
WS-18-71	Jun-06	7,990	91,624	26	99,640	-
(Downgradient)	Feb-08	102	6,541	16,600	23,243	76.7%
WS-18-101	Jun-06	198,000	34,133	41	232,174	-
(Downgradient)	Feb-08	2,920	97,315	24,900	125,135	46%

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Results

Riverbank - CVOCs

Riverbank Area		Concentration (ug/L)				Percent Reduction
Well	Date	TCE	DCE	VC	CVOCs	Total CVOC
Regulatory Screening Level		*3*	*70*	*2.4*	--	
WS-22-112	Jun-06	584	3,074	474	4,132	-
(within PRB)	Feb-08	ND	ND	ND	ND	99.99%
WS-11-125	May-06	22.9	10,557	2,490	13,069	-
(Downgradient, with MGP DNAPL)	Feb-08	ND	80	16.4	96.4	99.3%
WS-20-112	Jun-06	1,100	10,067	1,610	12,777	-
(Downgradient)	Feb-08	ND	0.73	ND	0.73	99.99%

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FFS Recommendations

- Alternative 3
  - EIB at source and riverbank
  - Potential to treat Area 1 TZW
  - Sustainable/low footprint remedy
  - Not selected by DEQ
- Alternative 2
  - EIB at source
  - Coordination with NWN P&T
  - Natural attenuation for Area 1 TZW
  - Selected by DEQ

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DEQ Basis for Selecting Alternative 2

- Iron from EIB PRB at Riverbank
  - Might create iron precipitates
    - Formation of ferric hydroxide
    - Interference with extraction system
  - Might result in downgradient impacts
    - Elevated iron in groundwater/TZW
- Jurisdiction
  - Benefits related to Area 1 under EPA oversight

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Iron Sources

- **Spent Oxide**
  - Strong correlation with depth (-0.92)
  - Site “background” ranges from ~37 to 46 mg/L
  - As high as 465 mg/L – Gasco
  - Source of elevated sulfate, cyanide
- **Organic-enhanced solubility**
  - Iron chelated by oxidized organics from MGP waste
- **MGP DNAPL**
  - 50 – 100 mg/kg
  - Upland and riverbank wells
- **Iron-cyanide complexes**

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Iron Sources

- Spent Oxide
  - 1966

Iron Sinks

- **Reactions in Low ORP Zone**
  - **Formation of ferrous carbonates, sulfides**
  - **Thermodynamically stable precipitation**
- **Confirmation with modeling**
  - **PHREEQC model confirms supersaturation for siderite ($FeCO_3$)**
- **Reactions Further Downgradient**
  - **Formation of ferric hydroxides**

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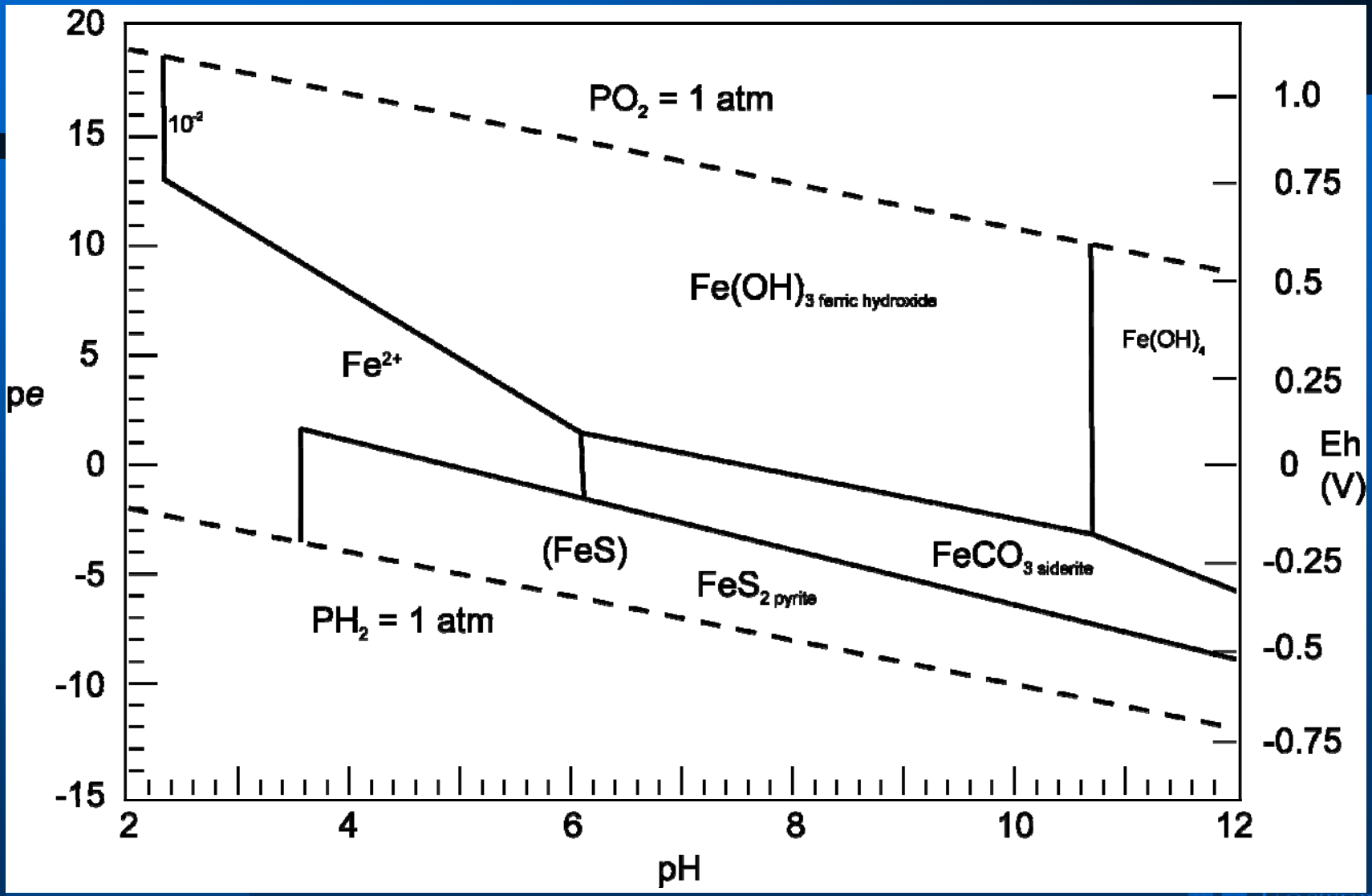
Results

Riverbank – Iron Precipitation



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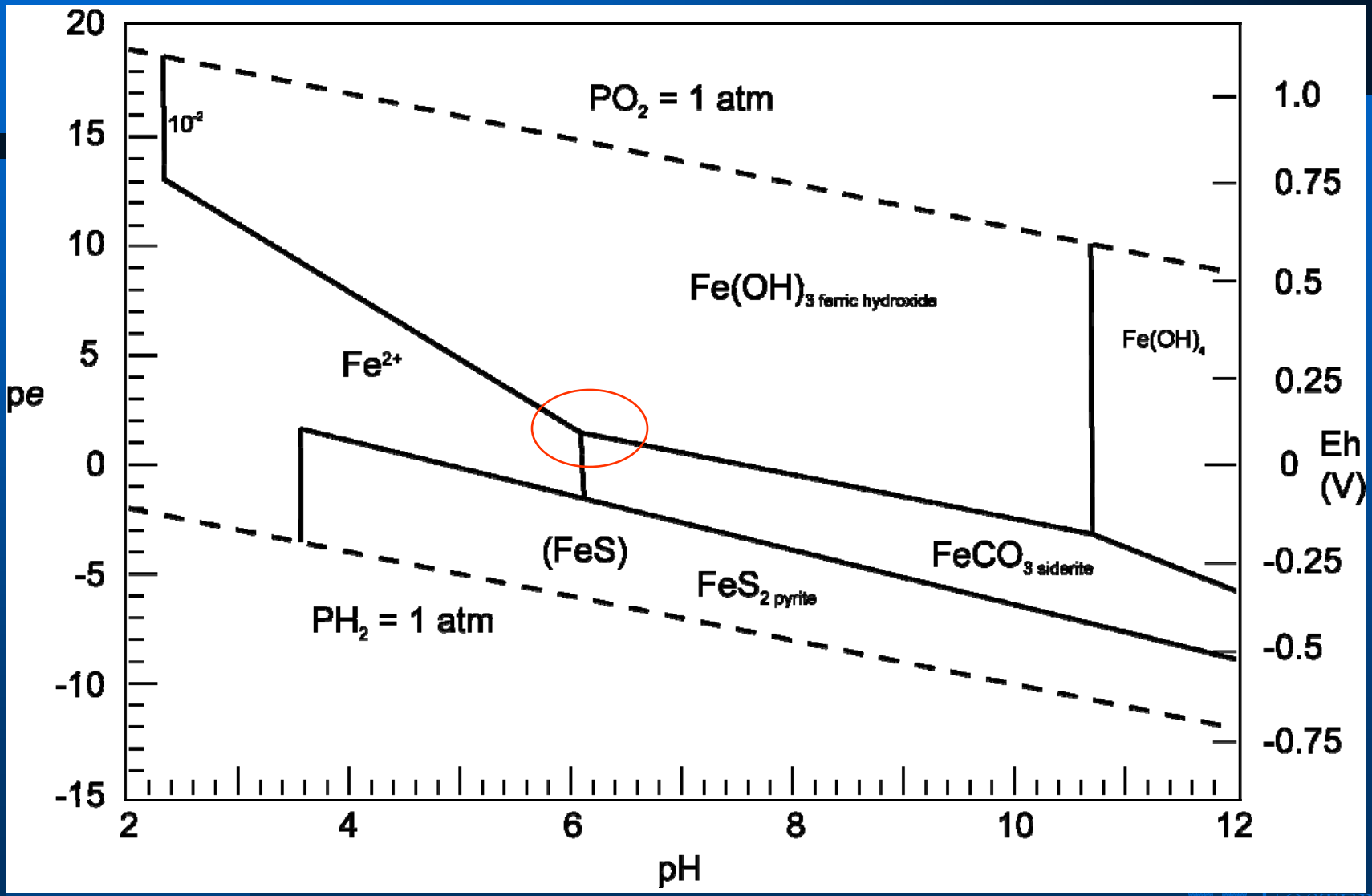
Results

Riverbank – Iron Precipitation – without EIB



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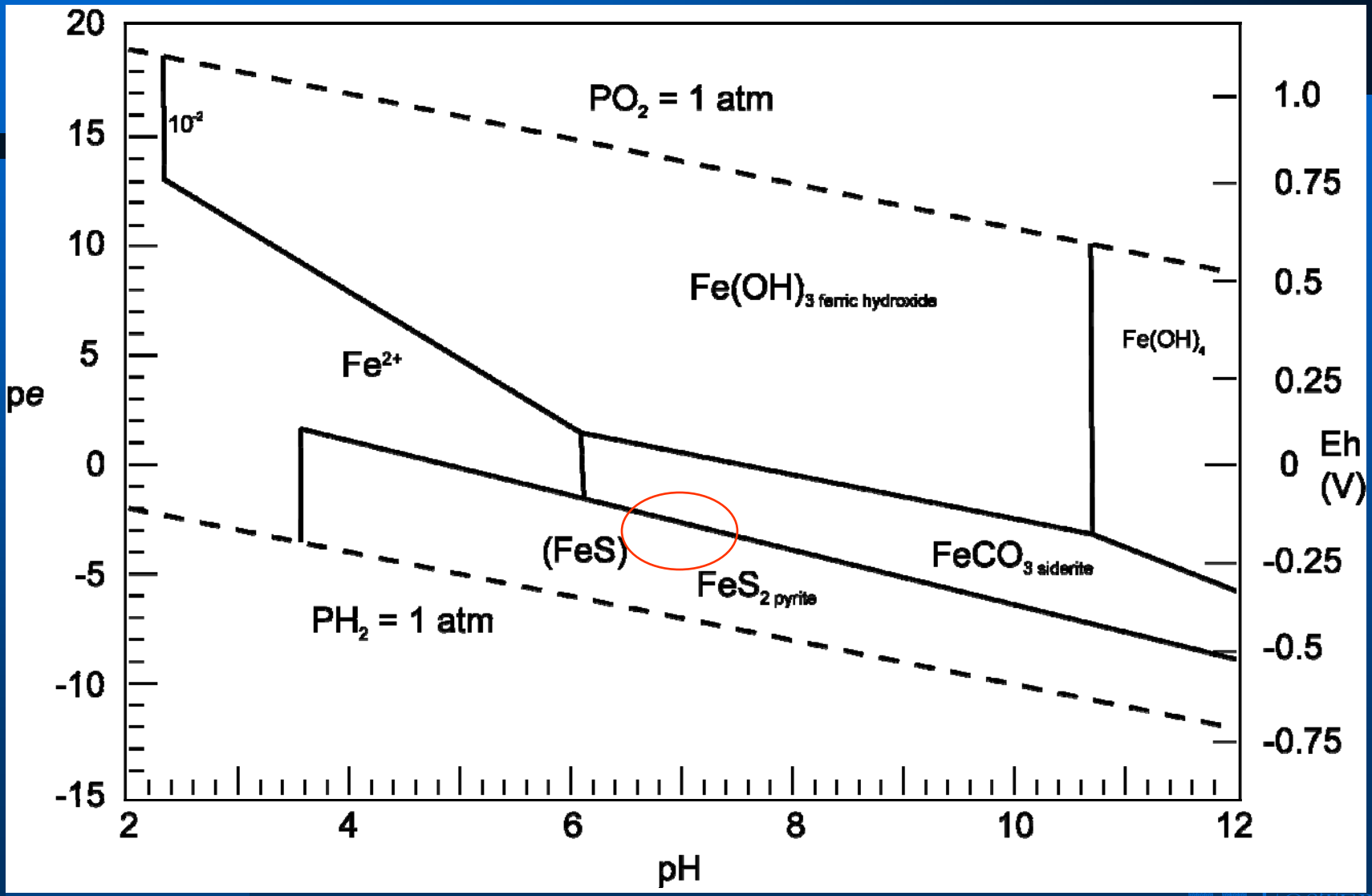
Results

Riverbank – Iron Precipitation – with EIB



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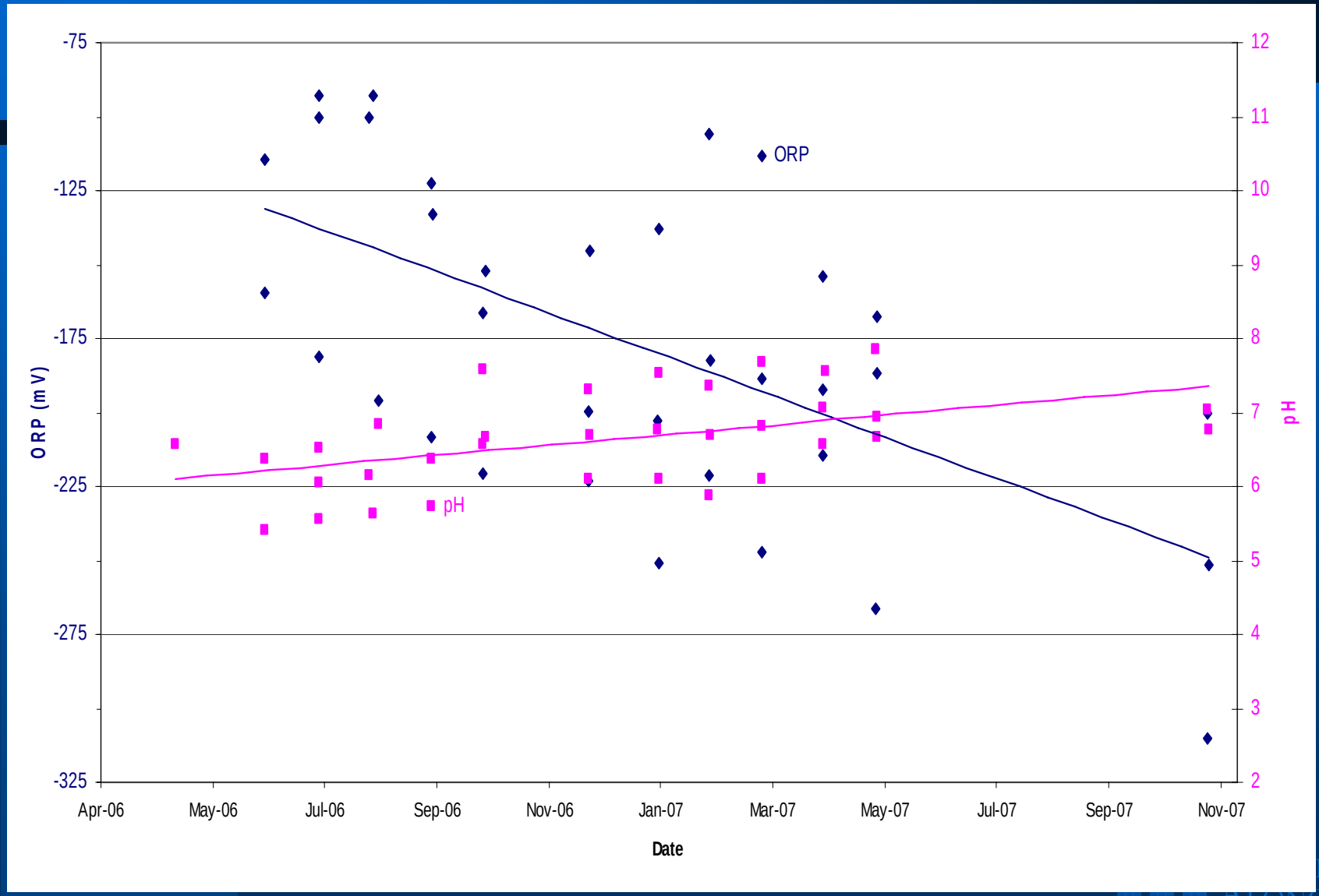
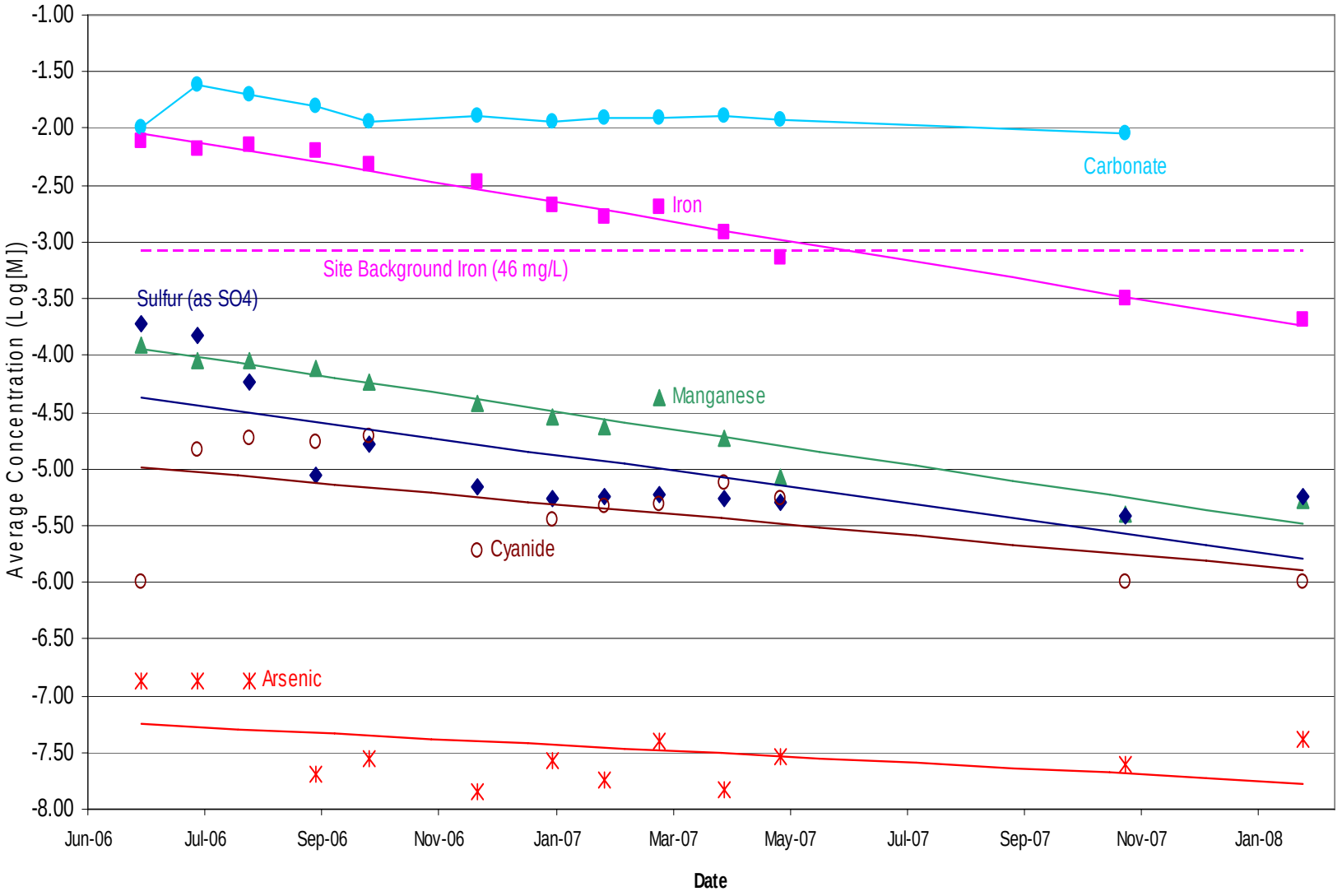
Results

Riverbank – ORP vs pH



Results

Riverbank – Reactive Species



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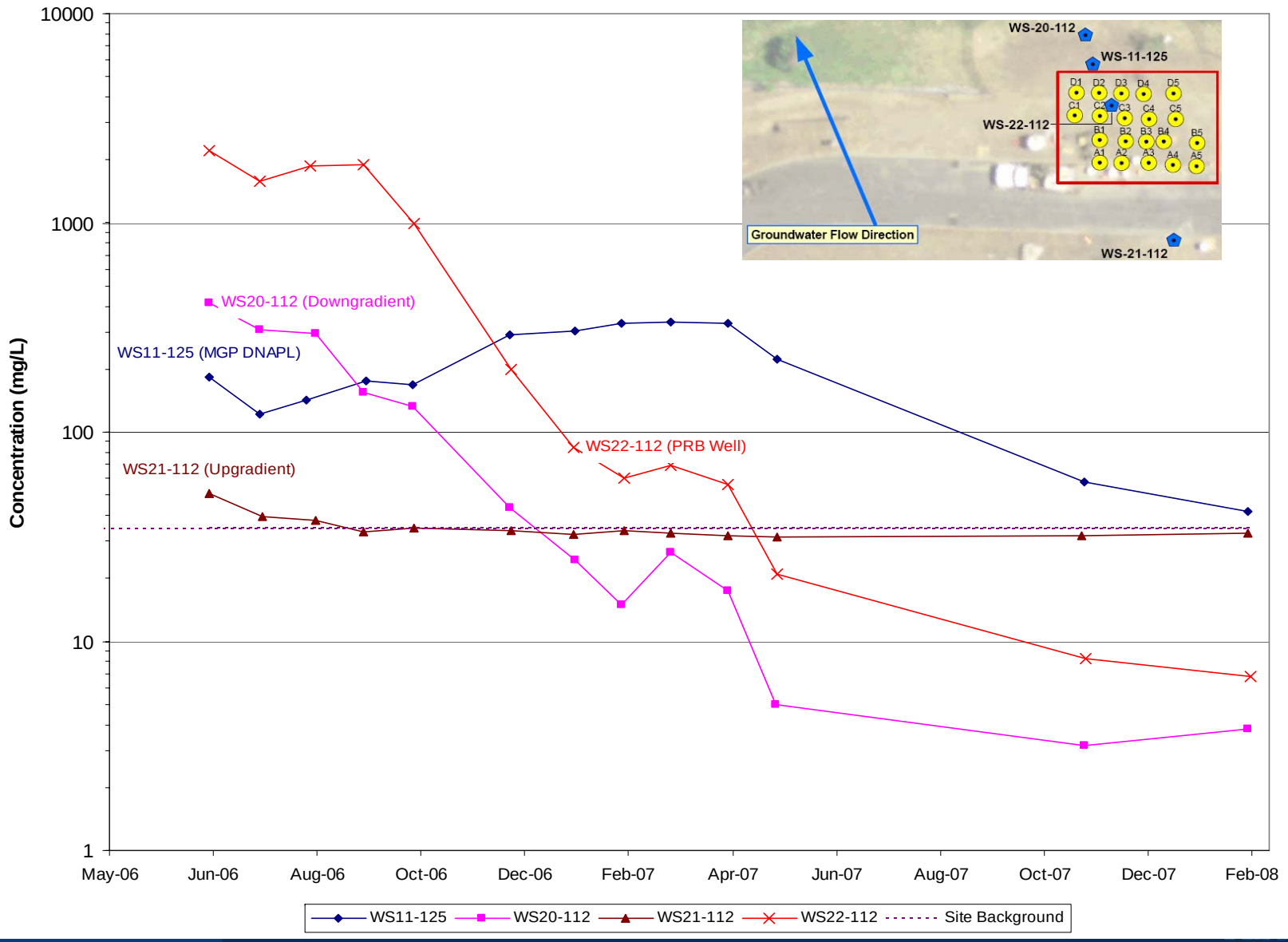
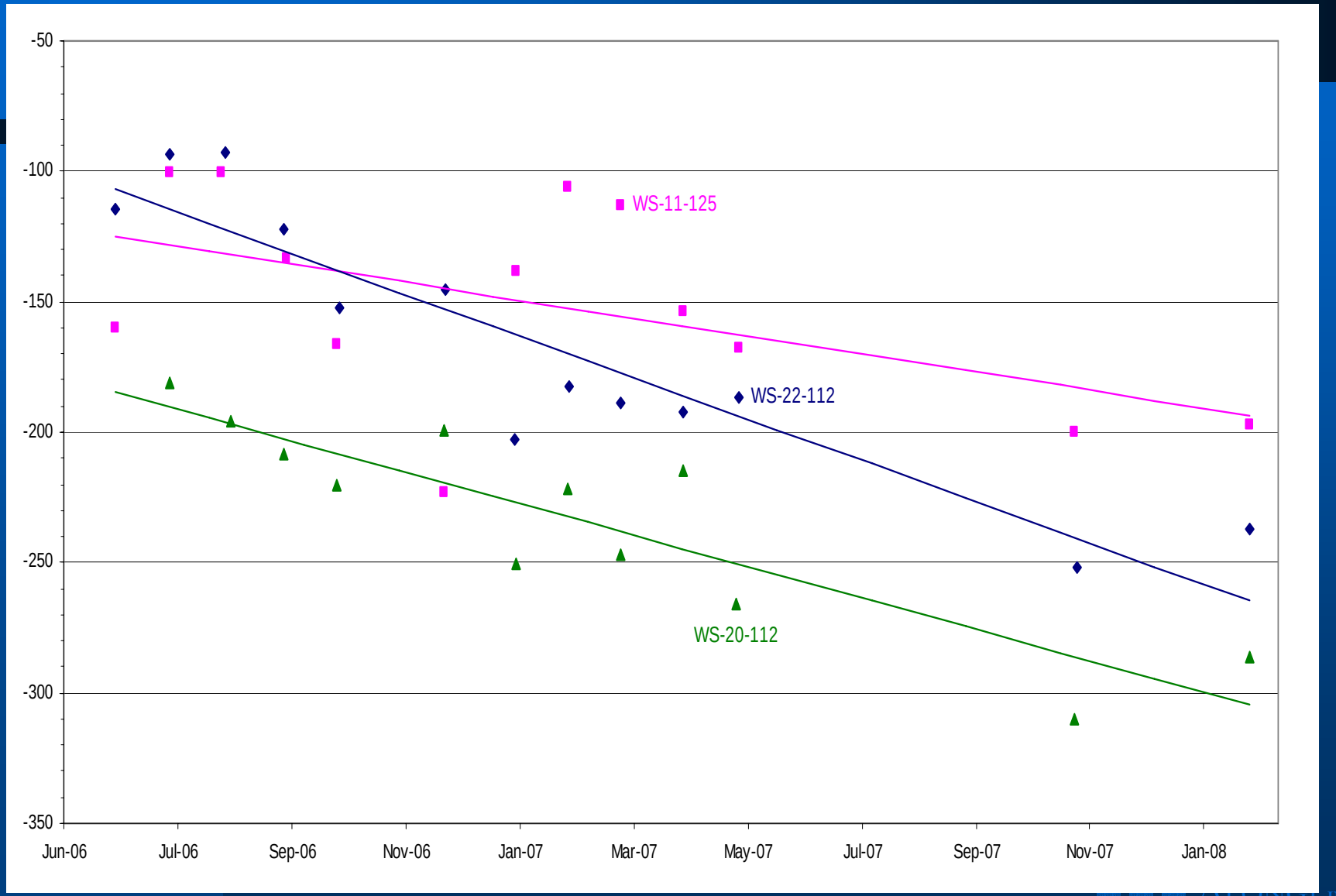
Results

Riverbank Zone - Iron



Results

Riverbank – ORP Detail



Conclusions

- Site background concentrations of iron in groundwater are elevated as a result of MGP waste.
- This iron is primarily present as ferrocyanide / ferricyanide anions and as Fe^{+2} cations, with enhanced solubility due to MGP-related organics.
- Enhanced reducing conditions resulting from implementation of an EIB PRB decrease the concentrations of iron (and manganese, sulfate, and cyanide) through formation of stable precipitates.
- Dissolved iron in groundwater is converted to stable solid minerals.

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Conclusions

- Elevated iron concentrations from implementation of an EIB PRB are *temporary* and reduced to *below background levels* through formation of stable precipitates.
- Pathway analysis confirmed by geochemical model.
- Geochemical model confirmed by field data.

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